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AUTHOR Smalley, Lee; Brady, Steve
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ABSTRACT

This report contains two tests designed to assess the level of technological literacy for a 12th-grade student in the United States in the 1980s. The tests are based on a literature review and on nine criteria for technological literacy that were established using the Delphi technique. This report contains a 27-item test, a list of works examined during the literature review, the criterion validation instrument, a copy of the round 3 validation questionnaire, a list of study participants, sample questions addressing each of the nine technological criteria identified, a sample 10-item test, and answers to both sample tests. (MN)

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TECHNOLOGY LITERACY TEST

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Project Director
Dr. Lee Smalley
UW-Stout
Menomonie, WI

Research Associate
Steve Brady
Graduate Student
UW-Stout

CE040854

Introduction

Our society has changed quite rapidly in the past two decades compared to past history. One element throughout the history of mankind has done more to bring about change and the way we live than all others. That element is called technology. While science has provided us with "truth" or "what-is", technology has made its impact with providing us with "know-how". (Smalley)

We are rapidly moving from what is often referred to as "old industry", which was typified by smoke stacks and people working on the assembly lines in factories to an office and the information age. Dominant in the "new industry" are the technological developments of computers, lasers, CAD/CAM, and systems that will stretch the mind. The thrust will be on productivity, efficiency, conservation and quality to complement the quest for quantity of the past. Technological development has and probably will continue at an ever accelerating rate. As this occurs, fewer and fewer people will understand these changes. If something is not done to prevent this we will become a technologically illiterate nation. It is becoming necessary for all of us to understand technology if we are to function as citizens in such roles as voters, workers, employers, consumers and as family members. It seems essential that a concentrated effort be made to educate the citizens of our nation so all will have a better understanding of technology and related issues. (Sterry)

Review of Literature

We have also been called to a state of awareness as reinforced by President Reagan in his 1983 State of the Union address. He alerted us to keep our "technological edge" in the world economic environment. "To do so we need to begin renewing the basics, starting with our educational system." (Reagan) One organization dedicated to the study of and promotion of technological literacy is the Council for Understanding of Technology in Human Affairs. Editor Edith Ruina, in the newsletter, The Weaver, states that; "Men and women, no matter how physically handicapped, must have opportunities to learn about technology and to apply this learning in their own lives." (1) Ruina supports the fact that everyone must take part in our technological society: "It is dedicated (The Weaver) to the proposition that for the people to participate fully as citizens in our society, they must comprehend how technology intertwines with other threads of social fabric, private and public." (5) This call for a more literate citizenry is also supported by Gordon Bowdon. "If we as a nation are to retain influence over our destiny, rather than become helpless victims of our own ignorance and the mystique with which we have surrounded science and technology, we must gain a better common understanding of these disciplines.... today, we are poorly prepared to make the political, economic, and social decisions that science and technology present to and impose on us." (5)

Many other writers and scholars have commented on the need for technological literacy.

Melvin Kransberg, a noted history of technology professor, in an address to an American Industrial Arts Association convention, said

> Science and technology differentiate our society from all that have gone before in human history and all that has taken place in other parts of the world. Nevertheless the students in liberal arts curricula are still being taught that Western civilization is based solely upon the Judeo-Christian-Greek tradition and scarcely anything is told them of the role of science and technology in developing our modern society. (10)

In a recent publication, Michael Dyrenforth has presented the case very carefully as to the challenge and possible implementation in education of a curriculum that would produce people who were technologically literate. He defines technological literacy as:

> The possession of a broad knowledge of technology together with the necessary attitudes and physical abilities to implement the knowledge in a safe, appropriate, efficient and effective manner. Technological literacy requires that one be able to perform tasks using the tools, machines, materials and processes resulting from technology. (32)

Russell Rumberger, commenting on the possibility that people will be forced into job and career changes, concludes that

> This points to an increased need for basic education and basic skills, and it goes beyond the simple notion of merely increasing math and science skills. There is much interest in increasing science skills and science requirements in schools today, but it may be every bit as important to increase workers' and students' communicative skills, analytical skills, and technological literacy. (6)

Lee Smalley developed a 10 question test related to technological literacy (Appendix F) as an example to students in

classes he teaches of what information might be included.

Technology Education

During the past few years there has been a growing concern over who will teach about technology. One area of education which has accepted that challenge is Technology Education. Technology Education is a part of general education which teaches general concepts of industry and technology, with technological literacy as its goal. "In a democracy where the claim is that all people should have a right to determine their future, a citizenry that is knowledgeable of technology is important. Therefore, as a part of their general education all citizens should study fundamental technological systems as routinely as they acquire other skills for literacy." (Richter 5) This philosophy is also backed by Robert Hendricks, past president of the Wisconsin Technology Education Association. "If students are to be intelligent and productive members of society, they must be provided a broad conceptual understanding of industry and technology." (40)

A great wealth of materials has been written about technology education, and more specifically the need for technological literacy. However, to our knowledge only two literacy tests have been developed in this area. One is by Dr. Jerry Richter, in the area of communication. This was his doctoral dissertation at West Virginia University. The other was a general technological literacy test developed by Anthony Gilberti, as a class project at Eastern Illinois University. Other content areas have been

successful in developing literacy tests such as agriculture and computer science. "If technological literacy is to be the theme for technology education (as the family is to be the theme for home economics), then there needs to be a test indicating, in broad terms, the level of technological understanding of individuals. Other fields of study such as music or biology, lend themselves to tests devised to show how much a person knows of a subject. So, it is assumed this method could also be used in the area of technology. (Smalley)

Methodology

The purpose of this study is to derive criteria which could be used to generate a test which indicates (in broad terms) the level of technological literacy for a 12th grade high school student in the United States in 1980's. Since technological literacy is a relatively new area, only a few "experts" could be found. The "experts" were identified by the work they have done in the area of technological literacy written in books, magazines, and professional conferences. (See Appendix D) One goal of research is to achieve a consensus toward test criteria. Therefore, the Delphi survey method was used. The Delphi consisted of three rounds, with the final round including sample test questions. Consensus was measured by the movement of opinions toward the mean.

A short review of the literature was also done prior to the development of the criteria and the sample test questions. After

the criteria was established from the Delphi, the sample questions were selected and a test developed.

Findings

The literature is very supportive of the necessity for technological literacy in our present culture. The concept is a popular one for many writers in a variety of disciplines and situations. The only concrete solution for schools has come from proponents of technology education, but these are usually in very general terms, and have not been translated into objectives, content, methods, activities and evaluation.

The purpose of this study was to attempt to find some consensus from experts on the criteria to be used on a test for 12th grade students' technological literacy. This was done with the Delphi technique and the results are recorded in Appendix C. There was enough agreement on all of the criteria, with no additions, to use the original list of nine.

The next step was to construct some sample test items from each of the nine criteria which would be appropriate to test the knowledge and understanding of the student. The multiple choice form was used because of the ease of standardizing the answer and flexibility of the question and answer. It is also a compromise between the T & F and an essay type question.

We feel that this study will allow others to go further in implementing specific educational programs that will increase the technological literacy of our citizens. Nothing less should be our goal!

Technological Literacy Test Items

1-1.* What invention was most important in the development of the first television set?
A. micro chip
B. solid state resisters
C. vacuum tube
D. satellite

1-2. If present trends continue, television sets in 2010 will become
A. cheaper, smaller, more reliable.
B. stay the same as 1985.
C. more expensive, bigger, need more repairs.
D. obsolete.

1-3. The American space exploration program was only possible because of the development of
A. new ceramic materials.
B. computers.
C. new navigational devices.
D. all of the above.

2-4. Why has solar energy not achieved the widewpread acceptance in 1985 that some had predicted 20 years ago?
A. conspiracy of the oil companies
B. not enough sun light
C. still more expensive to produce
D. lack of governmental research funds

2-5. Which procedure in the problem solving process would immediately follow the initial selection of a problem?
A. choosing best solution
B. brainstorming
C. testing hypothesis
D. selecting criteria

2-6. Which of the following resources would be most likely to be up-to-date on a technical problem or solution?
A. montnly trade magazine
B. technical book
C. research report
D. interview researcher

3-7. If you were buying a nail hammer and two brands were the same price, how would you choose which hammer to buy?
A. read the specifications
B. try each one for several weeks
C. ask someone who had used one or both brands
D. buy the one that looked the best

*refers to 1st criteria.

3-8. You find a product you recently purchased is unsafe. What is the best option for you?
A. tell all your friends about it
B. take it back to the store where you purchased it
C. call the local newspaper with the story
D. don't buy that brand again

3-9. When should you call an authorized repairman for your refrigerator?
A. when you hear a "funny" noise
B. when it won't work anymore
C. after you have taken it apart
D. when nothing has gone wrong for six months

4-10. Which one of the following careers would be most affected by the increased use of robotics?
A. assembly line welder
B. painter of tractor parts
C. assemblier of valve parts
D. all of the above

4-11. Which of the following usually results with the introduction of computers in the manufacturing process?
A. more skilled than unskilled jobs are created
B. more unskilled than skilled jobs are created
C. fewer people work harder
D. everyone works less and gets paid more

4-12. Which occupational area has increased the largest percent in the last 10 years?
A. farming
B. communication
C. manufacturing
D. sales and service

5-13. Which of the following magazines would you refer to for an explanation of the current technological problem?
A. Time
B. Popular Science
C. High Technology
D. all of the above

5-14. Which of the following problems would best be classified as a technological problem?
A. when should you plant a garden?
B. what car should you buy?
C. how do you insulate a home?
D. why do some people have red hair?

5-15. If you were to do a case study of a technological problem (example: how to control flooding from a river) which area would you study first?
A. where to build the dams
B. history of the river
C. how much would dams cost
D. what possible damage would dams do

6-16. Robots are being used to produce automobiles because
A. they produce better products cheaper.
B. there is a shortage of labor.
C. the Japanese use them.
D. American workers don't like dirty jobs.

6-17. Which one of the following will reduce the effectiveness of a passive solar system in a home?
A. small windows on the east and west sides
B. insulation in the ceiling and roof area
C. a good view through windows to the north
D. an overhang on the south side

6-18. What is the single major change in the last few years which has made the personal computer practical?
A. availability of large computers to connect to
B. development of the microprocessor
C. development of more software
D. ability of young people to operate the personal computer

7-19. What is a hologram?
A. laser produced 3D image
B. a telegram printed from a computer
C. one thousand grams on the metric scale
D. a message received from a satellite

7-20. Which term is <u>not</u> associated with personal computing?
A. Byte
B. K
C. Menu
D. R.O.D.

7-21. CAD/CAM means
A. communication assisted digital/computer aided memory.
B. computer assisted design and memory.
C. communication aided design and marketing.
D. computer aided design and manufacturing.

8-22. A third world country should not adopt high technology until they
A. can pay for it.
B. have the necessary infrastructure.
C. see another country like theirs have it.
D. can hire maintenance people.

8-23. Technological innovation
A. usually occurs in isolation.
B. is limited to the technical area in which it occurs.
C. can give rise to multiple social and economic changes.
D. is occurring at a slower pace now than it did 100 years ago.

8/24. Which is an advantage of nuclear energy?
A. plant can be built anywhere
B. doesn't use scarce resources
C. cheaper to build plants
D. cheaper to operate plants

9-25. What is the difference in new cars from those produced 40 years ago?
A. can't be fixed as easily by "shade tree mechanics"
B. don't last as long
C. need more repairs
D. are cheaper to operate

9-26. In the next 15 years in which type of jobs will there be the largest increase?
A. high tech industries
B. low pay/low skill
C. skilled labor
D. sales and service

9-27. More education beyond high school will
A. make you more specialized.
B. widen your options for a job.
C. cause you to lose money while others are working.
D. all of the above.

(Answers in Appendix G)

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APPENDIX A

First Letter Inviting Participants
to Take Part in the Study

December 1, 1983

Dear

With the move to technology education and the emphasis being placed on technological literacy, it is imperative that a test be developed to evaluate technological literacy. Dr. Lee Smalley and I are presently working on developing criteria for such a test for my masters thesis. This research is also being funded by a grant from the ACIATE. So far there have been partial attempts and philosophical positions, but no criteria for a technological literacy test has been developed. Such a test could be used in a variety of ways: to evaluate technology education programs, instructors, students, and for the general public to test their technological literacy. However, before a test could be developed, it will be necessary to establish criteria for such a test.

You have been selected because of the work you have done in the area of technological literacy with the hope that you would be willing to participate in our study. We will be conducting a three-round Delphi; each round would require about 15 minutes of your time. Since there are very few experts in this area, we would be most grateful if you would commit your time to this study.

On the following pages are some sample criteria which have been generated from related literature. Please judge each criterion on the three-point scale which includes: A-accept as is, O-omit, and M-modify. If you circle "accept" or "omit," you need not qualify your selection. If you circled "modify," please note your changes in the space provided. Also, please add any criteria you feel are missing.

Please return the instrument in the enclosed self-addressed envelope by December 21, 1983, if at all possible, so that subsequent forms may reach you without delay. The Delphi process preserves anonymity; therefore, names will not be used in tablulations.

Sincerely,

Steve Brady
Research Student

Dr. Lee Smalley
Research Advisor

Enclosures

APPENDIX B

CRITERION VALIDATION INSTRUMENT

Below you will find sample criterion for a test which will determine the level of technological literacy of an individual. As you evaluate these sample criterion keep this question in mind, " what are the characteristics, qualities, and abilities of a person we feel is technologically literate?"

Criteria for a technological literacy test	Responses	Modification
1. Connect past technological events to the present	A O M	
2. Have ability to solve technological problems	A O M	
3. Be a wise consumer of industrial products	A O M	
4. Understand the implications of career choices	A O M	
5. Read technical materials	A O M	
6. Knowledge restricted to specific industrial organizers (Communication, Construction, Manufacturing, Transportation)	A O M	
7. Ability to understand technical terms	A O M	
8. Aware of new and existing technology	A O M	
9. Ability to evaluate innovations as to their appropriateness	A O M	

List additional criterion on the back of this page

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APPENDIX C

CRITERION VALIDATION INSTRUMENT
Round 3 Questionnaire

Directions:

This instrument contains criteria which will lead to the development of a technological literacy test. Some criteria may be of greater importance than others. Please judge each criterion and circle a corresponding number which best expresses your opinion of the importance of each criterion. If you have any comments, please add them. Also, PLEASE ADD SAMPLE QUESTIONS WHICH COULD BE USED FOR A TEST.

	Unnecessary				Essential	Mean
1. Connect past technological* events to the present and be able to project alternative futures.	1	2	3	4	5	4.3

Comments:

Sample a.

Questions b.

2. Have ability to solve technological problems.	1	2	3	4	5	4.3

Comments:

Sample a.

Questions b.

3. Be a wise consumer/decisionmaker concerning technological products/ services.	1	2	3	4	5	4.4

Sample a.

Questions b.

*This term relates to industrial technology.

		Unnecessary				Essential	Mean
4.	Understand the implications of career choices in the field of technology.	1	2	3	4	5	3.5
	Comments:						
Sample	a.						
Questions	b.						
5.	Understand reading materials in technological areas.	1	2	3	4	5	3.1
	Comments:						
Sample	a.						
Questions	b.						
6.	Be able to apply knowledge to a wide variety of technological areas.	1	2	3	4	5	4.5
	Comments:						
Sample	a.						
Questions	b.						
7.	Knowledgeable of existing and emerging technologies.	1	2	3	4	5	4.6
	Comments:						
Sample	a.						
Questions	b.						

	Unnecessary				Essential	Mean
8. Ability to evaluate technology as to its appropriateness in our world.	1	2	3	4	5	4.7

Comments:

Sample a.

Questions b.

9. The ability to understand and adapt to change brought about by technology.	1	2	3	4	5	4.5

Comments:

Sample a.

Questions b.

Name: _____

PLEASE RETURN TO LEE SMALLEY, INDUSTRIAL & MARKETING EDUCATION DEPARTMENT, UW-STOUT, MENOMONIE, WISCONSIN 54751 BY APRIL 6, 1984.

APPENDIX D

Participants in the study

1. Dr. Myron Bender
   Department of Industrial Technology
   University of North Dakota
   Grand Forks, ND 58202

2. Dr. M. James Bensen
   Dean, School of Industry and Technology
   University of Wisconsin-Stout

3. Dr. E. Keith Blankenbaker
   Industrial Technology Education
   190 W. 19th Ave.
   Ohio State University
   Columbus, OH 43210

4. Dr. Paul W. DeVore
   Technology Education Department
   West Virginia University
   Morgantown, WV 26506

5. Dr. Jerry Rickter
   Industrial Arts and Technology
   Central Missouri State University
   Warrensburg, MO 64093

6. Mr. Gerald Stashak
   Davis Publishing
   DR-Z Printers Bldg.
   Worcester, MS 01608

7. Dr. John Wright
   School of Technology
   Eastern Illinois University
   Charleston, IL 61920

8. Anthony Gilberti
   Graduate Student
   Industrial Education Dept.
   University of Maryland
   College Park, MD 20742

9. Bruce Barnes
   Oak Grove Jr. High School
   1300 W. 106th St.
   Bloomington, MN 55431

10. Mike Jensen
    Rice Lake High School
    30 South Wisconsin Ave.
    Rice Lake, WI 54868

11. Donald Lauda
    School of Applied Arts and Sciences
    California State University
    Long Beach, CA 90840

12. Sharon Brusic
    Dept. of Industrial Technology
    Illinois State University
    Normal, IL 61761

13. Donna Boben
    7 Oak Ridge Drive
    White Bear Lake, MN 55110

14. Mike Dyrenfurth
    Department of Practical Arts
    University of Missouri
    Columbia, MO 65211

APPENDIX E

Sample Questions

Objective 1: Connect past technological events to the present and be able to project alternative futures.

- Describe the evolution of the laser
- Given our patterns of energy consumption, which conversion technologies will be the most appropriate in the year 2000?
- What significance did the invention of the transistor have for the future electronics?
- How is the space shuttle going to change the world from a military, communications, production, nuclear threat, colonization, etc. point of view?
- Describe the events that led to a major innovation and trace its lineage into the future.
- Describe an innovation which failed and identify alternatives for its replacement.
- The flyball governer was to the steam engine as the computer is to industrial robots. What are the future implications of this new technology?
- Why was the development of the vacuum tube important to the invention of the television?
- How might increased R&D in solar energy influence the way we live and work?
- How do we compare the muscle power world to the industrial and into the world of the future?
- What are some ways to study the future?

Objective 2: Able to solve technological problems.

- What are some stages in thinking creatively?
- How does one move through the technological processes in solving problems?
- As of today, which non-dependable energy source has the best chance of success and acceptance in the United States?
- How might inner-city mass transportation problems be minimized with the increase of cottage labor?
- In an area of declining natural resources, how might waste disposal be used for the creation of electricity and as a future resource?
- Generate a problem which would require library research and a laboratory to solve it.
- List three types of "authority" you could contact if you "recognize" a technological problem?
- Describe the process for identifying a technological problem.
- What can I do to see better in the dark?
- How can wave motion be converted to electricity?

Objective 3: Be a wise consumer/decision maker concerning technological products/services.

- What are the advantages/disadvantages of buying a new mini-van as compared to buying a new conventional van?
- List six technological criteria that should be used to evaluate household items/appliances before purchase.
- What is a "good" criteria to use when comparing similar products?
- Discuss the advantages and disadvantages of commercial packaging of products?
- Analyze XYZ product and describe the pros and cons of its use.

- Explain the consumers' options when products are unsafe, illogical, etc.
- Consider that all things were equal (octane rating, price, etc.) what type of gasoline automobile fuel would you purchase?
- Of the car, train, barge, pipeline, bus or plane, which is the quickest and most economical mean of moving people, coal, mail, furniture, nuclear waste, micro-chips etc.?
- How would you go about choosing a personal computer?
- Of the car, bus or plane, which is the most efficient and economical means of moving a 100 pound box of paper from New York City to San Francisco?
- What are the implications of continued use of coal as a fossil fuel?
- How does one pay more to get better value?

Objective 4: Understand the implication of career choices in the field of technology.

- How does technology both displace workers and create new jobs?
- What might be 5 new job titles that will exist in 5 years that are not now available?
- Which of the following careers would be most affected by the increased use of robotics in manufacturing?
- As of 1983 figures, how many times should the average person expect to be retrained due to changing technology?
- Due to existing technology, letterpress (printing) makes up only what percent of the printing industry?
- Explain how rapid change will alter the work place in your area of interest and how you will accommodate this change.
- Describe the range of skills needed in a career area and project these to the year 2000.
- Given a selected career field what alternative career roles are open to you?
- Compare the advantages and disadvantages of two technological careers.
- List emerging technological careers and indicate why they will become more important in the future.
- What jobs are most affected by the decline of smokestack industries?

Objective 5: Understand reading materials in technological areas written on the 10th grade level.

- Develop comprehension text questions based on reading a paragraph of technological material.
- Orally characterize a technological case study.
- Answer questions after reading a selected essay in technology.
- Critically analyze article XYZ.
- Apply reading materials to solve technological problem XYZ.
- What are the major journals being published for the general public that promotes technological literacy.
- How does one do a technical data search via computers?
- Review and react to an article in The Futurist, High Technology, Popular Science.

Objective 6: Apply technological knowledge to a variety of human concerns and situations.

- As a legislator, describe how new communications technology will enable you to keep in touch with your constituency.

- Based on the concepts, principles and skills learned about one piece of machinery, apply them to another - demonstrate your knowledge in a performance test.
- How does satellite communications affect information flow in multi-national industries and organizations?
- How does the improvement of (or R&D in) manufacturing technology affect innovations in medicine and health?
- How might CAD/CAM be used to increase productivity in the auto (etc.) industry?
- What are the major material categories?
- What are the 7 basic machines?

Objective 7: Knowledge of existing and emerging technologies.

- What are the basic parts of the computer?
- How does machine language work to aid us?
- How are fiber optical linkages able to replace coax cable bundles two inches or more in diameter, with increased efficiency and lower product cost?
- Artificial intelligence refers to _____.
- Robots may be used to _____.
- What is the main objective of the space shuttle at this time?
- What is a holograph?
- Identify three key existing technologies and describe their use.
- Identify three emerging technologies and describe their impact.
- List and describe "X" new technologies under development during the 1980's.
- Describe how a selected new technology is changing your life.
- Describe a materials processing technique developed in the past five years.
- What are the main parts of a computer?
- How does machine language work to aid us?

Objective 8: Ability to evaluate technologies as to its appropriateness in our world.

- How do you do a technology assessment?
- Identify 5 inappropriate and 5 appropriate uses of technology as they have impacted on people.
- Nuclear energy has both advantages and disadvantages as a power source for electricity. State two advantages and two disadvantages.
- Compare how a given technology is used in two different cultures.
- Compare the advantages and disadvantages that a given technology has to two different cultures.
- Critically analyze the use of technology in your community to satisfy needs in transportation.
- Critically analyze the adoption of technology in a developing country.

Objective 9: The ability to understand and adapt to change brought about by technology.

- Explain by example how technological change causes social change.
- Identify social changes resulting from the introduction of a new technology into a culture at some point in history.
- How can computers lessen the significance of the same jobs.
- Discuss how robots used in factories do repetitive tasks or dangerous jobs are a significant asset to the quality of employment and product.
- How do you set or prepare yourself to change?
- Indicate 5 examples where the failure to adapt had made people obsolete.

APPENDIX F

TECHNOLOGICAL LITERACY TEST

Put the letter which represents the correct answer in the blank to the left of the question. (Answers in Appendix G.)

_____ 1. The difference between manufacturing and construction stems from the
A. on-site or in-factory production.
B. size of the finished product.
C. number of products produced.
D. methods and materials used.

_____ 2. Which term is not associated with the laser?
A. fusion
B. incoherent light
C. holography
D. semiconductor

_____ 3. Tofu is
A. a corn product used in gasoline.
B. an old American Indian recipe now used for heart victims.
C. a beancurd product made from soybeans.
D. a synthetic food made by the Japanese.

_____ 4. Employment growth is projected to increase the most for which group by 1990?
A. technical workers
B. nonfarm workers
C. clerical workers
D. managers and administrators

_____ 5. CAD/CAM means
A. communication assisted digital/computer aided memory.
B. computer assisted design and memory.
C. communication aided design and marketing.
D. computer aided design and manufacturing.

_____ 6. E. Coli is a
A. simple organism found in the stomach.
B. scientist from Italy working on DNA.
C. process used in gene splitting.
D. simple enzyme used to break the DNA code.

_____ 7. Most robots presently used in industry are used for
A. sorting parts.
B. welding.
C. security.
D. communication.

_____ 8. Which one of the following will reduce the effectiveness of a passive solar system in a home?
A. small windows on the east and west sides
B. insulation in the ceiling and roof area
C. a good view through windows to the north
D. an overhang on the south side

_____ 9. Which one of the following was invented prior to 1800?
A. dynamite
B. bicycle
C. steam engine
D. stethoscope

_____ 10. Which one of the following strategic materials is most supplied from domestic (U.S.) sources?
A. aluminum
B. gold
C. natural rubber
D. silver

APPENDIX G

Answers to Technological Literacy Test on page 7.

1. C	10. D	19. A
2. A	11. B	20. D
3. D	12. D	21. D
4. C	13. D	22. B
5. B	14. C	23. C
6. D	15. B	24. D
7. C	16. A	25. A
8. B	17. C	26. B
9. A	18. B	27. D

Answers to Technological Literacy Test in Appendix F.

1. A	6. A
2. B	7. B
3. C	8. C
4. C	9. C
5. D	10. D